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ABSTRACT

Problem-based learning is an approach to professional education that stresses the use of real life problems in education. This paper focuses attention to the commitment of students to engage in the problem-based learning process. Subjects, approximately 1,300 undergraduates in a health sciences curriculum, completed a questionnaire covering various dimensions of problem based learning. In addition to commitment, these variables were investigated: (1) group functioning; (2) tutor functioning; (3) prior knowledge; (4) the quality of instructional materials; (5) time spent on study; (6) achievement; and (7) increased interest. As was hypothesized, commitment was found to be a potent determinant of achievement, representing one of the strongest relationships in the model. (Contains 1 figure, 3 tables, and 21 references.) (Author/SLD)

Motivation as a determinant in problem-based learning

MOTIVATION TO COMMIT ONESELF AS A DETERMINANT OF ACHIEVEMENT IN PROBLEM-BASED LEARNING•

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Motivation as a determinant in problem-based learning

Abstract

Problem-based learning is an approach to professional education that stresses the use of real life problems in education. Several attempts have been made to understand the intricacies involved in the process of problem-based learning. This paper adds to this work. It focuses the attention to the commitment of students to actually engage in the problem-based learning process.

Subjects were approximately 1300 undergraduates. The data were analyzed using a structural equations modeling approach. The following variables, besides commitment, were investigated: Group functioning, tutor functioning, prior knowledge, the quality of the instructional materials, time spent on study, achievement and increased interest.

As hypothesized, commitment turns out a potent determinant of achievement. In fact, it represents one of the strongest relationships in the model.

Introduction

Problem-based learning is an approach to professional education that stresses the use of real life problems in education. Students work in small tutorial groups and, while discussing these problems, formulate goals for self-directed learning. The learning resulting from these activities is considered constructive and contextually meaningful (Barrows, 1983; Norman & Schmidt, 1992).

This educational approach has methodological consequences for the organization of the student's learning process. Each year of study is sub-divided into periods of six weeks. These periods of six weeks are called "blocks". For the period of a block, the students are concerned with one theme. For this purpose a group of staff members compiles what is called a "block book". This book presents the problems concerning the theme of the block. There is also a bibliography of the literature that may be studied and the names and telephone numbers of staff members who can be consulted, and furthermore indications as to the possible approaches that students could adopt with the problems.

The students then start working on the basis of the problems in the block book. They meet together for a few hours twice a week in an educational group made up of about eight to ten fellow students of the same class. The educational group is arbitrarily assembled and its composition changes after each block. Each group has a member of staff as a "tutor". The tutor has the task of keeping an eye on the quality of the work within the group and promoting it, without concerning himself with the content of the discussions. He or she is therefore not the person who provides answers if the students are unable to do so. The tutor guides the educational group in purposeful cooperation in the set problems.

The tutorial method has some advantages (Pallie & Carr, 1987; Barrows et al.,1986). In the first place, the students are, in following this method, continuously being trained in dealing with and "learning to solve problems". When they have left university, they will forget many of the facts that they learned there, and, furthermore, a great deal of what they learned will soon be out of date. Skill in solving problems efficiently and in gaining access to new, relevant information is therefore of considerable importance.

Problem-based education appears to have a strong motivating effect too. The students feel that they are involved with reality and not that they just have to learn "dry" theory. The students learn social and communicative skills in verbal interaction with others. Furthermore regular group meetings provide better opportunities for making social contacts than is the case with a great mass of students attending lectures (Van Berkel et al., 1995).

The process in the educational group session

The process in the educational group can be divided into seven phases.

The students first ensure that all of the concepts that are used in this formulation are clear to everybody (clarifying). When there is sufficient clarity among them as to the nature of the particular problem, they make an inventory of the knowledge that they already have within the group on this subject (activation of prior knowledge). Various members of the group also put forward hypotheses: "couldn't it be that ....". In this brainstorming phase, a number of aspects of the problem emerge, and a number of questions arise that cannot immediately be answered. The group then together determines which aspects they want to investigate more deeply (clustering) and they make the arrangements among themselves: "Let us study these and those points for the following session". Less important matters or things that merely have to be looked up are then divided among the group members (formulating the learning goals). A group meeting lasting one or two hours ends with this type of agreement.

In the coming days, the members of the group occupy themselves individually with their share of the task, with the help of handbooks, literature, etc. They can also go to the "open plan study area" for this purpose: This is a complex of study rooms where there is sufficient literature and other material to enable them to pursue their study fruitfully (individual study). At the following group meeting an inventory is made of the results of this study (reporting the learning goals). This will often lead to a group discussion. Two members of the group may, for example, arrive at different answers to the same question, or the material that has been studied may not provide sufficient clarity. Being critically active with the information the student has found, increases the depth of insight into the problem, it helps to develop deep processing and it is, in academic training, a productive means of promoting quality. Sometimes a staff member is asked to come and help the group with a problem with which they are unable to progress any further. If the group feels they have made sufficient progress with a problem, although it has not been solved, it can be "shelved" and they can approach a new problem.

Modeling the process of problem based learning

Each new education process should prove itself on its value and merit. Several evaluation approaches have been developed to determine the effects of different educational programs. The classical approaches are concerned with questions such as "How much did students learn?" and "Did students learn more compared to the traditional program?" These questions focus on the outcome of the educational process; they ignore the influences of the instructional and learning processes on the final student-learning results. As Lawton (1980) stated, evaluation must be concerned with the total context of an educational situation, with the causes and its result (Gijselaers & Schmidt, 1989).

The theories tested have been formulated within the models-of-school-learning tradition represented by authors like Carroll (1963), Bloom (1976) and Cooley and Leinhardt (1990). These investigators maintain that learning within the context of a school can be described by three categories of variables. The first category is that of the input variables, notably student characteristics, teacher behavior and the adequacy of the learning materials. The second category comprises the intervening process variables: Learning activities carried out by students, time spent on study and features of the instructional process. The third category finally consists of cognitive output variables, e.g. achievement, and affective outcomes like interest in subject-matter studied (Schmidt & Gijselaers, 1990).

Several attempts have been made to understand the intricacies involved in the process of problem-based learning. In particular much research has focused on the question of what influences what in problem-based learning, for example, on the role of the tutor in problem-based learning. In particular, the issue whether her or his subject-matter expertise would be a help or a hindrance in the students' learning process has been the subject of much debate (e.g. Silver & Wilkerson, 1991). In addition, review studies have been carried out trying to assess the influence of problem-based instruction versus conventional, lecture-based instruction on student achievement and other variables of interest (e.g. Vernon & Blake, 1993).

A different approach have been taken by Gijselaers and Schmidt (1989) and Schmidt and Gijselaers (1990). These authors have tried to model problem-based learning, applying recently developed structural equations modeling techniques (Bentler, 1989). In their theory, they distinguish between what they call input variables to the learning process, such as the student's prior knowledge, the quality of the instructional materials, and the effectiveness of the tutor; learning process variables, such as the extent to which the tutorial group functions effectively, and the amount of time students spend on self-directed learning activities; and output variables such as the resulting achievement and increased interest in the topic studied. According to Gijselaers and Schmidt, prior knowledge, instructional materials and tutor all influence tutorial group functioning. Tutorial group functioning, in turn, influences time spent and interest, whereas time spent on learning influences the level of achievement. In a series of studies, they found empirical support for this model.

In summary, figure 1 outlines a causal representation of the learning going on within a problem-based curriculum.

According to the model, an increase in the magnitude of one of the variables characteristically causes an increase of the magnitudes of other variables. The arrows indicate the direction of the causal influences.

This paper extends this work. It directs attention to a variable that seems to have been overlooked by most authors, namely the willingness, or commitment, of students to actually engage in the problem-based learning process. In fact, it seems to be implicitly assumed that problem-based learning is so motivating in itself that students almost inevitably do what is required in these curricula (Boud & Feletti, 1997). Reality is different. Everyone involved in those programs knows about students who do not seem to be touched by the approach and continue their studies contributing little to the group's work. In addition, dropout is not uncommon in these programs (although less common than in conventional programs). In the present study, the amount of commitment demonstrated by students was considered a determinant of their success in such programs. We operationalized commitment in terms of attendance of tutorial group meetings and hypothesized that the more the students attended, the better their achievement would be, simply because attendance could be read as a measure of personal engagement that students feel towards their study. It is important to note that students who do not attend the tutorial group, still study the learning goals. They ask their fellow students which learning goals they had formulated so they can prepare themselves for the next group meeting.

Method

Subjects

Subjects were approximately 1300 undergraduates, enrolled in a problem-based, four-year, health sciences curriculum. The students worked in small tutorial groups of approximately ten students, guided by a tutor. The curriculum consisted of a series of consecutive courses or "units", each lasting six weeks. At the end of an unit, students fill in an evaluation form. The response rate on this form is 80%. For each of the academic years data from an average 30 of these units were included in the analysis.

Instruments

At the end of each unit, students were required to fill in a rating scale, consisting of 42 Likert-type items, covering various dimensions of problem-based learning as outlined in figure 1. Each item could be answered on a 5-point scale. In previous factor-analytic, reliability and validity studies, these dimensions have been shown to have good average intraclass-coefficients (as a measure of interrater agreement) and construct validity (Schmidt, Dolmans, Gijselaers, & Des Marchais, 1995).

Amount of prior knowledge ("PRIORKN") was estimated by asking students to what degree the unit's subject-matter linked with their prior knowledge. Quality of the problems in the block book ("BLOCKB") was measured by four items exploring to what extent the problems were clearly stated, stimulated group discussion, encouraged self-directed learning activities, etc. Tutor performance ("TUTORFUN") was measured by a fourteen-item rating scale: How well was the tutor informed about the unit's objectives? To what extent did he or she facilitate learning through stimulating questions? How much interest did he or she show in the students' learning? Small-group functioning ("GROUPFUN") was measured by two items inquiring about working-procedures, cooperation among group members, task-orientation of the group, etc. Time spent on learning ("TIME") was measured by asking students to give an estimate of the number of hours per week spent on self-directed learning activities. An achievement ("ACHIEV") test was administered to each student at the end of each unit. These so called block tests consist of 200 items. Attendance ("ATTEND") was measured by the tutor. Finally, intrinsic interest in subject-matter ("INTEREST") was measured by two items.

Procedure

Four year groups comprising 1300 students were studied. Data however were aggregated at the tutorial group level because achievement and other related variables related to members of the same tutorial group cannot be considered independent scores (Marsh, 1980). Doing so, aggregated data would obscure the individual variation.

Statistical analysis

A path analysis was carried out to assess the adequacy of the model (Bollen, 1989). In this study a recursive path analytic model was used because only one-way causal influences are represented in the model. This procedure yields several statistics that allow the investigator to assess the extent to which the empirical data fit the theoretical model proposed. There is no single best statistic which gives insight into the fit of the model. The best a researcher can do, is to calculate several statistics. The coherence of these measures indicates the model-fit.

Based on the simple chi-square and the degrees of freedom, a level of significance (P) is computed. In order not to reject the model, the value of P must be higher than .05.

Arbuckle (1997) argues that the Cmin/df is the best index of fit. This index is computed by dividing the minimum discrepancy (C) by its degrees of freedom. The ratio should be close to 1 for correct models.

Fo is an index which estimates the population discrepancy of the model. In general, the more the number of parameters in the model, the better the fit. Steiger (1980) suggested compensating for the effect of model complexity by the number of degrees of freedom. Taking the square root of the resulting ratio gives the population "root mean square error of approximation", called RMSEA (Browne and Cudeck, 1993). Its value must be less than 0.1000.

The goodness of fit index (GFI) is another index which indicates the fit of the model. Its value is between 0 and 1, where 1 indicates a perfect fit.

Results

Table 1 shows the intercorrelations, means and standard deviations of the variables.

There were 131 tutorial groups involved in this study. During one block period there are twelve meetings scheduled. In general, the meetings are well attended by the students (mean attendance percentage is 10.66/12 * 100 = 89%). The block test ("achievement") was scored on a 4-point scale (1 = insufficient, 4 = excellent).

There are four hypothesized dependent variables in this study: Attendance, small group functioning, time spent on study and achievement. It appears that there are relatively high significant correlations between attendance and small group functioning, amount of prior knowledge (negatively), time spent on study (negatively) and achievement. Small group functioning is highly correlated with intrinsic interest in subject matter, amount of prior knowledge, quality of the problems in the block book and achievement. Time spent on study shows high correlation with the quality of the problems in the block book. Achievement is highly correlated with attendance, small group functioning, and the quality of the problems in the block book.

However, not all the significant intercorrelations were part of the path analysis. Based on the significance of the beta weights, computed by a multiple regression analysis (stepwise), only those paths were selected which contributed significantly.

Figure 2 displays the major findings. Arrows indicate the hypothesized causal influences. Double arrows indicate correlations. The number beside the rectangles indicate the explained variance (R^2) which is of course dependent on influences of the independent variables. The following abbreviations were used in figure 2:

Achiev: Achievement

Attend: Attendance

Blockb: Quality of the problems in the block book

Groupfun: Small group functioning

Interest: Intrinsic interest in subject matter

Priorkn: Amount of prior knowledge

Time: Time spent on study

Tutorfun: Tutor performance

Chi-square for this model is 13.944 (df = 11; p = .236). The level of significance indicates that the hypothesized model is not rejected. Other measures of model fit are also satisfactory. The minimum discrepancy, C, divided by the degrees of freedom (Cmin/df) = 1.268; square root of the population discrepancy (Fo) corrected by the complexity of the model (degrees of freedom) (Fo/df) RMSEA = .045; Goodness of fit index (GFI) = .974.

To investigate the robustness of the model, the data set was divided into several subgroups. Firstly, the group (N = 131) was randomly split into two, group A and group B. Secondly, model fit was also computed in four groups. Each group represents the year of study (Table 2).

It appeared that the model was not rejected for four of the six groups.

Another analysis focuses on how the independent variables account for the variances of the dependent variables (see table 3). The percentages represents the amount of explained variance by the dependent variables.

The variance of the variable attendance (R^2 = .26) is explained by amount of prior knowledge (29%), quality of the problems in the block book (27%) and small group functioning (44%).

Conclusion and discussion

Motivation as a determinant in problem-based learning

This research extends the work of Gijselaers and Schmidt (1990). They had formulated a theoretical model of problem-based learning, following the ideas of Carroll (1963). The model has three categories of variables: Input, intervening and cognitive output variables. This research adds a new variables to the model: The commitment of students to actually engage in the problem-based learning process.

In general, the findings suggest that the hypothesized model fits the data adequately. There are some very interesting results. For example the negative causal relationship between the quality of the problems in the block book and attendance. It seems that poor quality of the problems leads to more attendance in the tutorial group. Apparently, students compensate a poor block book by attending the group. In contrast, a good block book leads to better functioning of the tutorial group, a high test result, and also to more time spent on study. Research into what makes a problem a good problem should be an area of primary interest to investigators in this field, as Schmidt and Gijselaers (1990) have already stated. Tutor performance has a relatively high influence (.39) on the functioning of the group. The absence of a causal influence of time spent on study on achievement seems remarkable. It appears that the amount of study time does not significantly lead to higher test scores.

The present findings concur reasonably well with the original Schmidt and Gijselaers findings. In fact, the addition of the new variable in the problem-based model ("attendance") increases the fit substantial. There is, however, one remarkable difference from Schmidt and Gijselaers. In the research we conducted, the variable intrinsic interest in subject matter turns out to be a independent variable, instead of an dependent variable. It is not clear how this result can be explained. In the model tested in our research, the influence of this variable on time spent on study is substantially. Omitting this variable results in a less good fit (although the model is still not rejected). Adjusting the model by introducing this variable as an independent variable leads to the model being rejected. So at least, our data suggest that the Schmidt-Gijselaers model is inappropriate in this respect.

Compared to the theoretical model of problem-based learning (figure 1) there are other inconsistencies. There is no path between prior knowledge and group functioning. This suggests that, contrary to theoretical expectations, more prior knowledge among group members does not generally improve the functioning of the tutorial group. Second, the model fits well without a causal relationship between group functioning and time spent on study. The theoretical model assumes a positive (and thus strong) relationship. These inconsistencies were also found by Schmidt and Gijselaers (1990), so it seems that in this respect the original theoretical model need to be adjusted.

As hypothesized, attendance of the tutorial group meetings turns out a potent determinant of achievement. Thus, the more students show their commitment to the work of their group by attending its meetings, the higher their achievement at the end of a unit. The (negative) relationship between attendance and study time is another indicator of this causal chain: Commitment to the group's work translates itself into less intensive self-study and higher achievement. In a way, the groups are functioning as study groups so that students do a great deal of their learning in the group and can therefore do without additional self-study at the cost to their achievement levels.

In conclusion: A real commitment to problem-based learning as expressed in the willingness to attend sessions seems to be a major factor in explaining achievement in this kind of curriculum. Further research in this area might prove fruitful and is warranted. The results reported here suggest that there is a need to rebuild the theoretical problem-based learning model.

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Figure 1: Causal Model Of Problem-Based Learning

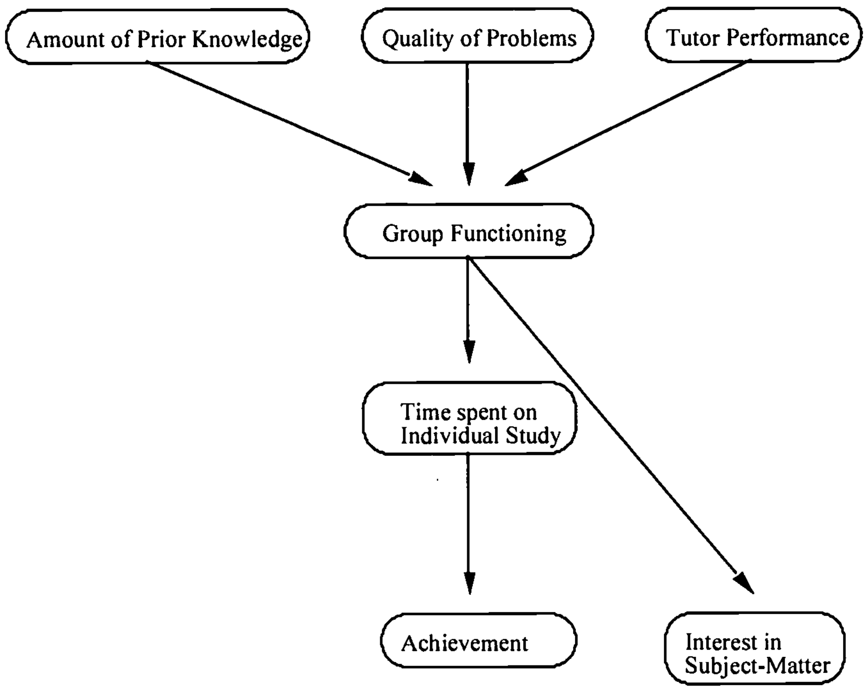

Table 1: Intercorrelations, Means And Standard Deviations Of The Aggregated Scores On The Variables (N = 131)
(Intercorrelations in italics were used as input in the path analysis)

	1	2	3	4	5	6	7	8
1. Attendance	-							
2. Tutor performance	.07	-						
3. Small group functioning	.21*	.60*	-					
4. Intrinsic interest in subject matter	-.01	.30*	.51*	-				
5. Amount of prior knowledge	-.36*	.14	.27*	.38*	-			
6. Time spent on study	-.29	.03	.08	.09	.09	-		
7. Quality of the problems in the block book	-.17	.45*	.64*	.73*	.54*	.30*	-	
8. Achievement	.26*	.12	.18*	.21	.15	.08	.30*	-
Means	1.66	55.37	7.63	7.83	3.45	17.20	14.76	3.04
Standard dev.	0.49	5.19	0.79	0.82	0.46	3.74	1.41	0.23
N of items	1	14	2	2	1	1	4	200

Table 2: Model Fit Of Several Subgroups

Group	N	Chi-square	Df	P	Cmin/df	RMSEA	GFI
Total	131	13.944	11	.236	1.268	.045	.974
Group A	60	22.462	11	.021	2.042	.143	.895
Group B	61	8.859	11	.635	0.805	.000	.997
Year 1	29	10.644	11	.474	0.968	.000	.926
Year 2	38	7.582	11	.750	0.689	.000	.961
Year 3	38	26.625	11	.005	2.420	.196	.884
Year 4	16	7.452	11	.761	0.677	.000	.896

Table 3: Percentages Of Variance Explained (R^2)

	Dependent variables			
	Achievement	Time spent on study	Small group functioning	Attendance
Intrinsic interest in subject matter		15%		
Amount of prior knowledge		15%		29%
Quality of the problems in the block book	53%	35%	54%	27%
Attendance	47%	35%		
Tutor performance			46%	
Time spent on study				
Small group functioning				44%
Total R^2	0.18	0.20	0.53	0.26

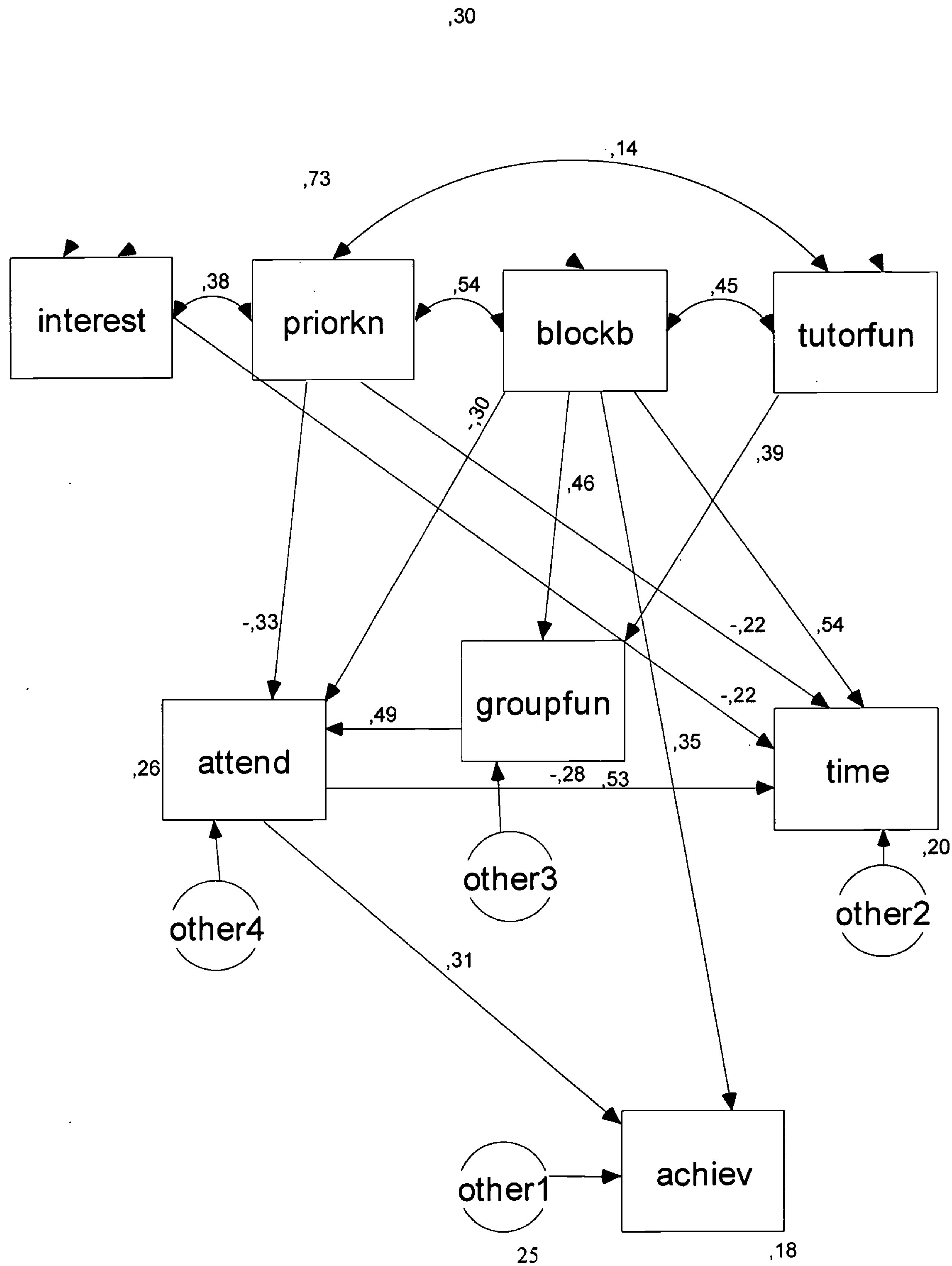

Figure 2: Path model of problem-based learning

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